ous estimates of capital and operating and maintenance expenditures incurred in 1981, the most recent year for which comparable data were available.[3] Pollution control capital expenditures as a percent of total capital expenses in 1981 appear to be in the range of 13 percent to 15 percent (using McGraw-Hill and Commerce Department estimates, respectively). Further, according to the McGraw-Hill survey, pollution control expenditures as a percent of capital spending have been declining steadily from a high of 19.9 percent in 1979 to 5.2 percent in 1984. (This is consistent with the facts that by the mid-1980s many of the capital investments associated with air and water pollution control had already been made for existing facilities, and that capital expenses to comply with the emerging hazardous waste rules are substantially smaller.) Annual costs (including operating and maintenance expenses) of pollution control were estimated in the range of $1.2 billion to $1.6 billion in 1981.

It is difficult to select the best estimate from among the existing expenditure and cost figures. Differences in methodology, in underlying assumptions, and in the types of pollution control costs included give no basis for preferring one estimate to another.[4] Annual capital costs in the range of $500 million, even though declining over the 1979-1984 period, would represent a significant portion of total investment in the iron and steel industry. Given the constraints on the industry's ability to raise capital in the last several years, it is possible that environmental control expenditures could have displaced some investments in "productive" activities. The extent to which this displacement may have contributed to the industry's current problems is discussed in the next section.

The Economic Impact of Pollution Control Expenditures

One, now dated, study of the economic impact of environmental regulations on the iron and steel industry suggests that the increased expenditures may

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3. The variations in the reported estimates reflect different survey methodologies and engineering assumptions underlying the estimates, and the different media covered by the estimates. An earlier CBO analysis (*Environmental Regulation and Economic Efficiency*, 1985) discusses the various advantages and disadvantages of expenditure estimates versus engineering cost estimates of pollution control. That study also examines the various problems connected with existing expenditure surveys.

4. For example, a CBO hazardous waste analysis (*Hazardous Waste Management: Recent Changes and Policy Alternatives*) estimates annual costs for the primary metals sector of complying with the hazardous waste regulations at around $1 billion. It is unclear whether expenditures for hazardous waste control are included in all the estimates reported here.

have had a negative effect on industry performance. Arthur D. Little, Inc. (ADL), estimated in 1981 that compliance with existing air and water regulations would cost the industry an average of $600 million a year in capital expenditures from 1980 through 1984, and possibly $1.5 billion a year in the 1986-1990 period. [5] According to the study, these costs would have the following impacts by the year 1990 (assuming full compliance with all current and projected future requirements):

- Shipments would be 96 million tons in 1990 rather than 105 million tons;

- Job losses by 1990 would be in the range of 40,000 among workers directly involved in iron and steel production;

- Steel imports would increase by 1990 to around 42 million tons (compared with 17 million tons in 1979); and

- All firms with production costs 15 percent to 25 percent over the industry average would be adversely affected (the study did not make an estimate of plant closings).

These results provide a worst-case analysis of what might have happened to the steel industry as a result of environmental regulations if the demand for steel products had increased after 1980 rather than falling off. The study's underlying assumptions as to the future of the industry proved to be far too optimistic. [6] At the same time, it was too negative in its estimate of the stringency of environmental regulations; it failed to take into account the special regulatory treatment that has been accorded the iron and steel industry in the past, nor did it allow for a learning-curve effect that would tend to lower annual costs. [7]

Actual developments in the early 1980s seem to have overridden the Arthur D. Little framework. Nevertheless, if the ADL estimates are taken

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5. Arthur D. Little, Inc., *Environmental Policy for the 1980s: Impact on the American Iron and Steel Industry* (Report to the American Iron and Steel Institute, 1981).

6. For example, ADL assumed that the industry would operate at 90 percent capacity over the relevant period, and increase shipments from 92 million tons to 105 million tons.

7. During the Carter Administration, the steel industry reached at least one agreement with the U.S. Environmental Protection Agency to extend compliance schedules in exchange for increased spending on modernization as part of the Steel Tripartite Committee meetings.

as upper bounds of the potential impact of environmental regulations on an expanding industry, they indicate that the impact would have been significant over the 1984-1990 period. As things turned out, the changes in domestic and international markets for steel appear to have outweighed any effects from environmental regulations. No doubt the environmental regulations may have affected decisions concerning continued operation of some older, high-cost facilities. But downward pressures on employment were also in part the result of shifts from older facilities to new, less labor-intensive plants--more probably a function of increased demand for certain steel products than of environmental costs. (As noted below, however, pollution cost differentials might have the effect of encouraging newer electric arc furnace capacity, which would mean lower overall environmental costs to the industry than those estimated here.) Finally, the ADL estimates were derived from estimates of gross environmental costs, and probably do not reflect tax credits available to the industry and other forms of preferential treatment of pollution control expenditures that lessened their impact.

This qualitative conclusion is supported by simulation results obtained from the CBO iron and steel model. These simulations capture the post-1980 steel downturn. For illustrative purposes, CBO assumes that 12 percent of total capital expenditures (the average reported by McGraw-Hill over the period 1967-1984) were devoted to environmental protection over the period of the model, and that without environmental controls these funds would have been available for "productive" capital investment. The CBO model interprets this as meaning 12 percent more gross investment per year, and makes it available to reinvest over the historical and forecast periods of the model. Although such a simulation is artificial and somewhat contrived, it provides an answer to the question of what might have happened if the iron and steel industry had not had to invest heavily in pollution control plant and equipment over the last 15 years.

The CBO steel model indicates that several effects, or a combination of all of them, would have been likely. First, the extra capital might have spurred additional investment in steelmaking capacity, even in the face of declining demand. The result, of course, would have been even further declines in capacity utilization. Second, the additional funds might have been returned to investors in the form of dividends as after-tax profits rose. Finally, increased investment in labor-displacing technology might have accelerated employment losses in the industry. The actual outcome, of course, would depend on how the increased capital was distributed in the industry. (The CBO model assumes that the capital would be available to both integrated and minimill producers.) [8]

8. See Appendix B for details.

The CBO simulations should be viewed as illustrative rather than demonstrative. Nevertheless, they are consistent with an iron and steel market that is constrained by falling demand. Essentially, the simulations highlight the fact that a larger pool of capital, whether from fewer environmental regulations or from some other source, would not likely have led to significant differences in the industry's performance in the face of rapidly declining markets. The CBO analysis does not suggest that environmental regulations have been costless to the steel industry. Rather, it argues that the available evidence does not support the contention that the costs of environmental regulations have contributed significantly to the industry's current difficulties.

The foregoing discussion has treated the steel industry as homogeneous, ignoring the way in which pollution control costs are actually distributed among different sectors of the industry. The minimills tend to be substantially less effluent-intensive than the integrated steel works, and so it would be reasonable to presume that capital costs for pollution control are a substantially smaller percentage of overall costs in the minimill sector. Plausibly, this might give minimills a competitive advantage in the industry and lead to their more rapid increase. The available data do not provide a firm basis for testing this hypothesis, but the high level of expenditures on environmental control in the industry suggests that cost differentials could be large if the sectors of the industry are characterized by very different levels of pollution problems.

International Competitiveness

It is often argued that mandatory environmental expenditures have placed the U.S. iron and steel industry at a competitive disadvantage relative to foreign producers. This follows from the assumption that major foreign producers do not face the same level and stringency of environmental controls. There is reason to question the assumption. Studies in the last five years have found that most foreign producers of iron and steel face similar, and in some cases higher, environmental protection costs. For example, the average pollution control investment per ton of steel in the period 1973 to 1980 was $4.06 for the United States and $4.52 for Japan. A CBO analysis of total environmental expenditures in several countries reveals little difference in the nature or scope of environmental controls in West Germany, Canada, or Japan. [9] Price differentials between domestic and foreign steel

9. Congressional Budget Office, *Environmental Regulation and Economic Efficiency* (March 1985).

are thus more likely to represent differences in other costs than those of environmental regulation. In some countries, however, the impact of similar environmental expenditures may be less than in the United States where the regulatory programs tend to be more restrictive and possibly less cost-effective.

It is worth noting that comparisons of environmental controls in steel-producing countries tend to focus on the more developed countries. Their conclusions may not hold for steel produced in less developed countries such as Korea or Mexico, where pollution control may seem less urgent than the need for foreign exchange. Thus, it is possible that steel produced in these countries enjoys a cost advantage over U.S. steel because of fewer environmental controls as well as because of lower labor costs and more efficient plants.

REGULATION IN THE FUTURE

This chapter has presented a retrospective look at the relationship between environmental regulation and the current status of the iron and steel industry. Of greater importance from a policy point of view is the outlook for environmental regulation in the future, and whether events looming on the horizon may lead to an efficient restructuring of the steel industry. No easy answers are at hand, but it is possible to draw certain conclusions about the future role of environmental regulation in steel that may serve as a basis for evaluating alternative policies.

First, it is important to recognize that the steel industry has already made the bulk of its financial commitment to most of the known pollution problems, although it will continue to face annual operating and maintenance expenses associated with air and water programs. Depending on the outcome of current revisions in the National Ambient Air Quality Standard for particulates (the major air pollutant in steelmaking), few additional air requirements of substantial magnitude seem likely. Major revisions in this standard could, however, lead to significant costs. Similarly, new water pollution control requirements seem unlikely unless the Environmental Protection Agency adopts a stringent program to address toxic hot spots (areas where the best available technology is not able to meet water quality standards).

The biggest uncertainties arise from efforts to regulate hazardous and solid waste disposal. Current hazardous waste rules identify several steel by-products as hazardous (such as pickle liquor, electric arc furnace dust, and coal tar wastes) and therefore subject to the increasingly stringent Resource Recovery and Conservation Act (RCRA) Subtitle C requirements. The major steel waste by-product, slag, is classifed as a solid waste (if it results from steelmaking activities) or is currently exempt from regulation (if it results from blast furnace operation). Regulatory programs under RCRA involving hazardous and solid wastes are in a state of flux, however. Depending on the outcome of pending regulatory decisions concerning matters such as the classification of slag as a solid or hazardous waste, requirements for operation of solid waste units, and the definition of a disposal unit for corrective action purposes, RCRA programs could have major financial implications for the industry. Estimates of the potential costs are highly uncertain at this time.

As already indicated, the burden of environmental control expenditures is likely to fall most heavily on the integrated sector of the industry. To the extent that minimill penetration continues, environmental expenditures in the industry will probably decrease in comparison to their historical levels regardless of the final RCRA rules for iron and steel wastes. Assuming that no new environmental problems are found, the impact of environmental control costs on the steel industry will be increasingly marginal and relate mainly to integrated facilities.

CHAPTER VI

IMPLICATIONS FOR POLICY

The decline of the integrated sector of the steel industry has given rise to Congressional concern that capital formation in the industry is inadequate.[1] This paper has examined the interactions between capital formation in steel and various aspects of federal policy--including tax, trade, antitrust, environmental, and science policy. It has consistently found that federal policies have not been a significant deterrent to steel industry investment. In fact, many aspects of federal policy--most notably, a series of trade restraints--may have promoted investment.

Another consistent result of this analysis is that the current low levels of investment--or *disinvestment*--in the integrated sector of the steel industry are more a symptom of that sector's decline than a cause of it. Simulations with the CBO steel model indicate that greater levels of investment in the recent past would not have led to major changes, particularly in employment and output. Nor would they in the near future. In Chapter V, for example, the steel model was used to simulate the industry's recent past under the assumption that expenditures on new plant and equipment were substituted for capital expenditures on pollution abatement equipment from 1974 to the present. The resulting increase in output, as measured by the model, was negligible. Similarly, in Chapter IV, results were reported suggesting that the effects of the "reinvestment" provisions of the Trade and Tariff Act of 1984 (Public Law 98-573) are likely to have a small effect on the steel industry's performance, particularly when compared with the effects of the accompanying quotas themselves.

The small effect of higher levels of investment on the performance of the steel industry can be explained by the primary sources of the industry's decline: falling steel consumption per unit of gross national product, cost disadvantages in labor and raw materials, and inhospitable economic conditions--most notably, an exchange rate that has penalized U.S. manufacturers. Higher levels of capital formation in the steel industry would not expand the market for steel, nor make U.S. labor, ore, or energy cheaper,

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1. See, for example, House Committee on Science and Technology, *New Technology and the Future of Steel* (June 1986).

nor countervail the competitive advantage enjoyed by such producers as Korea, Taiwan, and Mexico as a result of high dollar exchange rates. Neither will increased capital formation improve employment in the steel industry, since investment in new equipment tends to be labor displacing.

The finding that increased capital formation would not of itself qualitatively change the prospects for the domestic steel industry is consistent with the belief that capital markets tend to allocate funds efficiently among industries. The low level of investment in the domestic steel industry (including pronounced disinvestment in the integrated sector) reflects the low rates of return such investments offer. As noted by one steel executive:

> Reduced demand for our products makes investment less attractive to outside investors because the meager profits simply are not attractive enough to repay the investors in a reasonable time. Also, borrowing for investment becomes more difficult, more expensive, because lenders perceive lending to a poorly performing company, understandably, as high risk. 2/

If capital markets are correct in seeing investment in the steel industry (most notably, the integrated sector) as an inefficient use of scarce resources, then any federal effort to stimulate such investment would be at the expense of other, more valuable economic activities. For that reason, other ways of assisting the steel industry may be preferable. Among these are:

- Spurring research and development to bring about innovation;
- Providing incentives to restructure the industry; and
- Smoothing the transition to a smaller industry.

RESEARCH AND DEVELOPMENT

Previous CBO studies have discussed the rationale for federal funding of research and development. 3/ The most important argument is that private incentives to increase R&D are limited; the returns to scientific discoveries

2. Op. cit., p. 15.

3. See Congressional Budget Office, *Federal Support for R&D and Innovation* (April 1984) and *Federal Financial Support for High-Technology Industries* (June 1985).

cannot be fully appropriated by the innovator, since imitators can use the discovery to their own ends. But the rate of return to R&D in general is high, and the social rate of return is higher than that realized by the innovator. 4/

A variety of federal initiatives already exist (see Chapter III) that address the technological problems found in the steel industry. In 1985, the Committee on Science and Technology proposed federal funds for the creation of industrywide research facilities that would allow the major steel firms to work collectively on a range of advanced research problems, among them direct reduction of iron ore, refractory wear, and cleansing of particulates and sulfur from gases. The major steel firms have a common interest in producing such innovations, but may hesitate to fund them because of the appropriability problem mentioned above and because of the firms' poor cash flow. Centralizing these efforts would also avoid duplication in research efforts. Once the usefulness of any innovation was proved, firms would use their own resources to build pilot plants for commercial demonstration.

Given the poor financial condition of most major integrated steel producers, there may be technological opportunities that can be explored only by a joint public-private undertaking. Such a program, however, raises questions of *time*, of *management*, and of *coordination*.

Time

The innovations produced by a steel industry research center would probably require lead times of a decade. Laboratory and demonstration facilities would have to be built, pilot plants constructed, and the capital stock of the steel industry changed to incorporate the innovation. But many integrated steel producers are in immediate financial jeopardy, and major innovations 10 years hence can do little to change their current situation.

Management

An industrywide research facility also poses difficult management issues. First, the decision to create such a facility, primarily aimed at integrated steel producers, presupposes that this would be the most productive way of modernizing the industry. But a research agenda aimed, for example, at

4. See Congressional Budget Office, *Federal Support for R&D and Innovation* (April 1984), pp. 29-30.

broadening the range of products that could be produced by minimills might offer more valuable results than one aimed at innovation in the integrated sector. A second issue is that of access to the products of such a research facility. Limiting access might be detrimental to competition in the industry in the long term. Yet, unlimited dissemination of research results would leave individual firms with little incentive to participate in the funding and operation of the facility. Moreover, a number of U.S. firms have recently formed relationships with foreign steel interests. If innovations produced by a government-funded facility were shared with foreign firms, this would exacerbate the problems of the domestic industry.

Coordination

If a national public-private research facility was set up, it would probably be superimposed over the diverse steel-related R&D activities already existing in the federal government and in private industry. Research would have to be coordinated to avoid duplication of existing efforts. Perhaps a panel of government and industry representatives and outside experts could develop a publicly-assisted research agenda. Such a panel might make the government a more credible partner in the steel R&D effort, and give steel firms more incentive to participate in joint R&D ventures with the federal government. But at the same time, it might choke off potentially profitable private research and raise mangement issues similar to those discussed above.

EFFORTS TO RESTRUCTURE THE STEEL INDUSTRY

Massive overcapacity is a severe impediment to technological innovation and new investment in the steel industry. If the market for steel products should improve in the future, firms with old facilities that are now not in service might be tempted to operate them at marginal cost despite the fact that they are not profitable. This overhang of capacity thus acts to lower future prices, and may be a severe disincentive to new investment in the steel industry.

Despite the fact that these facilities are unprofitable on their own merits, steel firms may be reluctant to retire them. For one thing, if a firm retires capacity before its competitors do, it may be ceding a share of the market to them should conditions improve. Moreover, as shown in Chapter IV, the costs of retiring facilities may be very large, including the engineering "shut-down" costs of scrapping or mothballing a facility, payments to labor (particularly for retirement benefits), and ongoing costs of long term supplier contracts for raw materials that cannot be abrogated simply because of plant closures. Finally, closing facilities may place some producers in technical bankruptcy because of covenants on outstanding loans.

A cabinet-level Interagency Working Group chaired by the Secretary of Commerce is now investigating how federal policies may affect the decision of steel companies to retire antiquated facilities. A report from this group, expected in the first half of 1987, will shed greater light on options for bringing about prompter retirement of obsolescent steelmaking facilities. Among these options are: waiving antitrust restrictions to allow greater consolidation among existing steel firms; changing the tax treatment of the write-offs associated with plant retirements; assuming all or part of the pension burden associated with plant closings; or developing an explicit sectoral policy toward the steel industry in which these forms of assistance would be exchanged for participation by the involved firms in worker retraining and relocation, or in steelmaking research and development, or in the establishment of new facilities embodying technological advances. The interests of firms in different positions within the steel industry may converge on this issue. Stronger firms may welcome the exit of weaker firms if their capacity is permanently withdrawn from the market, while weaker firms may accept federal assistance in meeting the costs associated with their exit.

MANAGING THE TRANSITION TO A SMALLER INDUSTRY

If most projections, including those of the CBO steel model, are correct, the steel industry, notably the integrated sector, will be smaller in the future than it is today. The costs of this shrinkage to the federal government are likely to be quite high. On one side will be the loss of interim tax revenues from unprofitable firms and out-of-work employees. On the other will be increased federal outlays for unemployment benefits, food stamps, and other social services. Additional bankruptcies in the steel industry would also put the Pension Benefits Guaranty Corporation under severe financial stress, forcing it to call upon the Treasury for federal assistance.

One way of handling these costs would be to pay for them as they arise. Since many of them are directly related to the slowness of unemployed resources to find alternative employment, they would be minimized if the shrinkage took place in a growing economy. Under ideal conditions, capital and labor from the steel industry would move into other industries, and their unemployment would be transitory.

But the inevitable contraction may occur in regions already burdened by relatively high unemployment. In that case, the costs to the federal government of the transition to a smaller steel industry could be minimized by some forward design. One option would be to focus federal policy on workers who had been displaced. 5/ The government could use its resources to set up a relocation and retraining program for such workers. The principle of providing some type of assistance to displaced workers has been part of U.S. trade law since the Trade Adjustment Assistance (TAA) program was enacted in 1962, and is also recognized in the Job Training Partnership Act of 1982 (JTPA). The TAA program, however, emphasized cash assistance rather than retraining; only 1.4 percent of workers participating in TAA undertook and completed a retraining program, and of those only about one-third took jobs for which they had been trained. The TAA program is authorized at $29.9 million for fiscal year 1987. Title III of the JTPA also funds some training for dislocated workers. In fiscal year 1987, $200 million, or about 5 percent, of JTPA's $3.7 billion budget is authorized for this purpose. The Administration's 1988 budget proposal would combine TAA and JTPA programs into a single program to aid all dislocated workers, budgeted at $986 million in the first year.

If the federal government participated in a joint government-industry agreement to retire excess steel capacity, retraining funds could be targeted to those facilities closed under the agreement. Job retraining could be emphasized in the program design, or made mandatory as a condition for unemployment insurance payments.

Proponents of retraining programs note that the retraining of workers increases the mobility of economic resources, promoting economic change and long-term economic growth. Critics, on the other hand, note that job displacement occurs continually throughout the economy as a result of changes in tastes, economic conditions, trade, and a variety of other factors; a special retraining policy for one set of workers is therefore seen as arbitrary and inequitable.

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5. See Congressional Budget Office, *Has Trade Protection Revitalized Domestic Industries?* (November 1986) and *Dislocated Workers: Issues and Federal Options* (July 1982).

APPENDIXES

APPENDIX A

DESCRIPTION OF THE CONGRESSIONAL BUDGET OFFICE STEEL MODEL: A SMALL-SYSTEMS MODEL

The CBO model of the U.S. steel industry is a partial equilibrium econometric model, specifically designed, estimated, and simulated to address the concerns in this study. The three subsectors of the industry, the integrated, speciality, and minimill sectors are combined for modeling purposes. 1/ The model includes 15 stochastic equations and 10 identities. Estimates of the coefficients are obtained using national time series data (1965-1985). The 25 endogenous (solution) variables in this system of equations are:

- Import price of steel;
- Domestic price of steel;
- Imports of steel;
- Exports of domestic steel;
- Domestic production of steel;
- Domestic capacity;
- Domestic shipments;
- Demand for domestically produced steel;
- Domestic capacity utilization;
- Domestic average operating costs;
- Domestic total operating costs;
- Domestic markup;
- Domestic capital costs;
- Domestic capital stock;
- Domestic gross investment;
- Domestic net investment;
- Domestic employment;
- Domestic share of production, electric arc furnaces;
- Domestic steel revenue;
- Domestic after-tax profits;
- Domestic before-tax profits;
- Apparent domestic consumption;

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1. This model is a revision and extension of work done for an earlier CBO study, *The Effects of Import Quotas on the Steel Industry* (July 1984). The later version explicitly incorporates an investment function to assess better how an increase in near-term profits would affect capital formation and the competitive position of the industry.

- o Import share of consumption;
- o Imports of Japanese steel;
- o Japanese share of imports.

Estimation and Simulation

The model provides a representation of how the domestic steel and imported steel markets might perform over the historical (1973-1985) and forecast periods (1986-1992) under a variety of different assumptions. The model is, of course, subject to the same limitations as any econometric model, and depends critically on the data used to obtain coefficient estimates. 2/ The present model is only a generalization or abstraction of the forces that affect the industry. Yet the model provides a consistent way to ask "what if" questions pertinent to this analysis.

Model simulations consist of solving the system of equations for each relevant time period, given the coefficient estimates and values of exogenous variables, so as to provide assessments of how various policies or changes in exogenous variables may affect the industry. The values of the exogenous variables for the 1986-1992 period are based on CBO's medium-term economic projections.

Market Characterization: Domestic and Imported Steel as Imperfect Substitutes

The CBO model follows the convention of treating the markets for imported and domestically produced steel separately. 3/ This market representation depicts domestic and imported steel as imperfect substitutes with relatively large cross-price effects.

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2. All econometric models are at best different ways of organizing and presenting data. In this one, the simulation results depend on coefficient estimates obtained from national time series data. Several estimators were used to analyze the sample data. For example, single-, two-, and three-stage least squares estimators were used, in combination with an auto-correlation correction, to obtain sets of coefficient estimates. These were subjected to extensive structural analysis to determine which set of coefficients provided the most stable and "reasonable" dynamic multipliers within and outside the sample.

3. See Robert Crandall, *The U.S. Steel Industry in Recurrent Crisis* (Washington, D.C.: The Brookings Institution, 1981), p. 130, and the Federal Trade Commission, "Prehearing Brief for Carbon and Certain Alloy Steel Products, Investigation No. TA-201-51 before the International Trade Commission" (May 1984), Appendix A, p. 7.

For example, a decrease in the import price resulting from an appreciation in U.S. currency elicits a reduction in the demand for domestic steel and an increase in the demand for imports and in the import share of apparent domestic consumption. This assumes no change in the outputs of steel-using industries such as automobiles, construction, oil and gas exploration, and so forth.

Import Supply

The import supply curve is perfectly elastic; import prices are represented as a function of foreign capacity utilization, a three-year distributed lag of exchange rates, foreign operating costs per ton, and time. The demand for imports is a function of import prices, domestic prices, dummy variables, and output indexes of steel-using goods. The Japanese share of imports appears as a function of the exchange rate for major trading partners, the Japanese exchange rate, and a dummy variable representing periods of voluntary trade restraints (1969-1972, 1979-1982, and 1985).

Domestic Supply

The domestic supply function is a composite function, consisting of a markup function and an average variable cost function. The use of the composite function permits the possibility of oligopolistic market reactions, without ruling out marginal cost pricing.

Increases in capital stock and the additional penetration of electric arc furnaces (minimills) occur as investment increases. Each is determined by after-tax profits and rental rates of capital. As capital stock and additional penetration of electric arc furnaces increase, reductions occur in average variable costs, resulting in greater industrywide profit margins. Domestic production, capacity, and supply increase in subsequent periods as a result of investment in a previous period. Average variable cost, the difference between domestic price and markup per unit capital costs, is also expressed as a function of domestic supply, wage rates, the price of scrap, and the prices of coal and iron ore. The underlying production technology exhibits variable returns to scale. Profits, total variable costs, capital costs, capacity utilization, exports, revenues, after-tax profits, and import share obtain as identities.

Domestic and Import Demand

The demands for imported and domestic steel appear as functions of domestic and imported prices, output indexes of steel-using products, notably automobile production and real fixed investment, and various dummy variables. When the quotas become binding during the simulations, the short-run equilibrium import price becomes an inverse function of the import demand. Domestic demand adjusts accordingly.

RESULTS OF POLICY SIMULATIONS

In this analysis, the CBO steel model was used to depict industry outcomes under a variety of assumptions. As with any econometric model, the CBO steel model is at best an approximation of the industry's responses to different situations, and its estimates of future outcomes are based on extrapolations of past behavior. 1/ Given these limitations, the model does provide a set of internally consistent estimates of how various factors affect the steel industry. This appendix presents results generated by the model; the results support the statements made in the report.

Table B-1 presents the effects of limiting steel industry imports to 23 percent or 20 percent of the U.S. market over the 1986-1992 period.

Table B-2 presents the effects of refunding the investment tax credit to the steel industry, under the Tax Reform Act of 1986.

Table B-3 presents the effects of eliminating steel industry pollution-abating capital expenditures and replacing them with expenditures on new plant and equipment directly related to steel production.

1. See Appendix A for details of the model.

TABLE B-1. EFFECTS OF QUOTAS ON THE STEEL INDUSTRY

Industry Outcomes	Actual 1985	1986	1987	1988	1989	1990	1991	1992
U.S. Shipments (In millions of tons)								
Base case	72.7	69.3	73.3	74.6	73.8	72.2	70.5	68.7
23% quota	72.7	72.5	72.7	72.9	73.9	74.6	75.0	75.4
20% quota	72.7	75.3	75.9	76.1	77.2	77.9	78.3	78.7
Import Share (In percent)								
Base case	25.3	26.4	22.0	21.3	23.4	25.4	27.3	29.3
23% quota	25.3	23.0	23.0	23.0	23.0	23.0	23.0	23.0
20% quota	25.3	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Domestic Steel Employment (In thousands)								
Base case	155.2	144.6	145.0	144.9	137.4	126.1	113.4	100.2
23% quota	155.2	151.1	146.3	140.4	135.8	130.7	124.1	116.5
20% quota	155.2	156.8	154.7	148.7	143.5	137.7	130.4	122.2
Gross Domestic Investment (In billions of 1972 dollars)								
Base case	2.8	2.5	2.5	2.6	2.7	2.8	2.9	2.9
23% quota	2.8	2.5	2.6	2.6	2.7	2.8	2.9	3.1
20% quota	2.8	2.6	2.6	2.7	2.9	3.0	3.1	3.3

SOURCE: Congressional Budget Office steel model.

TABLE B-2. EFFECTS OF INVESTMENT TAX CREDIT REFUNDING ON OUTPUT, EMPLOYMENT, AND INVESTMENT IN STEEL

Industry Outcomes	Actual 1985	1986	1987	1988	1989	1990	1991	1992
Total U.S. Shipments (In millions of tons)								
Base case	72.7	69.3	73.3	74.6	73.8	72.2	70.5	68.7
1988 tax refund	72.7	69.3	73.3	74.6	73.9	72.4	70.6	68.8
Domestic Consumption (In millions of tons)								
Base case	96.1	93.0	92.0	93.0	94.4	95.3	95.8	96.2
1988 tax refund	96.1	93.0	92.0	93.0	94.4	95.3	95.8	96.2
Import Share of Consumption (In percent)								
Base case	25.3	26.4	22.0	21.3	23.4	25.4	27.3	29.3
1988 tax refund	25.3	26.4	22.0	21.3	23.4	25.4	27.3	29.3
Domestic Steel Employment (In thousands of dollars)								
Base case	155.2	144.6	145.0	144.9	137.4	126.1	113.4	100.2
1988 tax refund	155.2	144.6	145.0	144.9	137.4	125.8	113.1	99.9
Capital Stock (In billions of 1972 dollars)								
Base case	14.8	14.8	14.2	14.0	13.8	13.6	13.4	13.2
1988 tax refund	14.8	14.8	14.2	14.0	14.0	14.0	13.4	13.2
Gross Domestic Investment (In billions of 1972 dollars)								
Base case	2.8	2.5	2.5	2.6	2.7	2.8	2.9	2.9
1988 tax refund	2.8	2.5	2.5	2.6	2.7	2.8	2.9	3.0

SOURCE: Congressional Budget Office steel model.

TABLE B-3. IMPACT OF REDUCED ENVIRONMENTAL CAPITAL EXPENDITURES ON THE IRON AND STEEL INDUSTRY

Industry Outcomes	1985	1986	1987	1988	1989	1990	1991	1992
Capital Stock (Quantity index)								
Base case a/	15.4	14.8	14.2	14.0	13.7	13.6	13.4	13.2
Policy b/	19.6	19.4	19.2	19.3	19.5	19.7	20.0	20.1
Production Capacity (In millions of tons)								
Base case	139.7	135.1	130.7	129.2	128.8	128.6	128.4	127.9
Policy	142.3	138.2	134.5	133.7	134.1	134.9	135.5	136.0
Capacity Utilization (In percent)								
Base case	64.7	64.0	69.2	71.0	70.3	68.9	67.3	65.7
Policy	64.2	63.4	68.3	69.8	68.9	67.3	65.5	63.7
After-Tax Profits (In millions of 1972 dollars)								
Base case	-570	-480	460	880	950	910	840	770
Policy	-360	-260	710	1,170	1,260	1,230	1,180	1,110
Domestic Prices (In dollars per ton)								
Base case	250.6	250.3	251.4	251.8	251.7	251.5	251.2	250.9
Policy	249.3	249.0	250.0	250.2	250.0	250.0	249.2	249.0

SOURCE: Congressional Budget Office steel model.

a. All reported results are simulated by the CBO steel model.

b. Capital expenditures for environmental protection over the 1967-1984 period are assumed to be available for "productive" investments.